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MAY 81 J ZHONG, Q LI

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by

Ji Zhong, Qun Li

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PREPARED BY:

TRANSLATION DIVISION
FOREIGN TECHNOLOGY DIVISION
WP-AFB, OHIO.

A TWENTY YEAR'S SURVEY OF LASER SCIENCE AND TECHNOLOGY IN CHINA (III)

The correspondent Ji Zhong the reporter Qun Li

AN OVERVIEW OF THE CAPITAL

We will report here to the readers about the 20 years of development of a laser laboratory--the laser laboratory of the Physics Institute of the Chinese Academy of Science.

The fact that in 1960 Maiman designed the first ruby laser stimulated scientists in Beijing. The scientists in the Chinese Academy of Science are no exception. They were led by Mr. Chang Zhu-san, and a research group composed of seven members was organized in 1962 in the spectroscopy laboratory. Laser device research was immediately started. In less than three months, they observed completely repeated output characteristics of laser oscillations in ruby laser devices. In the meantime, they started to develop the first coaxial pulsed pumping new laser source in the world*. Today, this laser laboratory has been entirely changed. It is now composed of nearly 100 members and an appreciable amount of research apparatus. Members in the laboratory include one research fellow, four research associates, 62 research assistants and engineers, 26 low level and business support employees. Many papers from this laboratory are published in related journals and magazines each year, reflecting its research accomplishments. While international scholar exchanges are frequent, this laboratory appears to be the right spot for the visit, lecture and research of foreign scholars. The research

*"Coaxial pulsed laser excitation light source", "Science Communications", 1963, no. 11, 39.

activities in the laboratory are primarily on laser physics, laser spectroscopy, nonlinear optics, laser devices and optical communications data bases.

For 20 years this laboratory has accomplished much in the development of laser devices, basic research and applications of laser technology. For example, in order to upgrade the output power of ruby laser devices, they studied various Q modulation techniques systematically. Finally, they first reported the benefits of replacing a Kerr box with the ADP and KDP type electro-optical crystals as Q switches. The overall capability of a nanosecond switch was comparable with the leading product in the world then *. This suggestion provided a stable tool for the development of synchronous measurement on the interaction of high power lasers and matter. They also launched research on the oscillation characteristics of coaxial ruby laser devices. The energy, power, field distribution, and modular structure of the output light beam were measured. In the meantime, the electro-photo method and high speed photography were used for time-space scanning observation. They measured the fluorescence spectra of laser oscillations and observed many phenomena such as mode competition, mode jumping, mode beat, etc. of laser oscillations. The tunneling effect of laser oscillations was also recorded. They realized that improvement of the quality of materials is the most important element for upgrading the quality of laser beams. The structures of the harmonic oscillation cavity were selected experimentally. In 1964-1965, they systematically and extensively investigated the methods for upgrading the output energy of ruby laser devices. In order to provide systematic research on ruby laser devices, the laboratory started research on the crystal growth of rubies and performed experiments on the vaporization of multi-layer medium film and nonlinear optics. Meanwhile, theoretical investigations were also performed in parallel,

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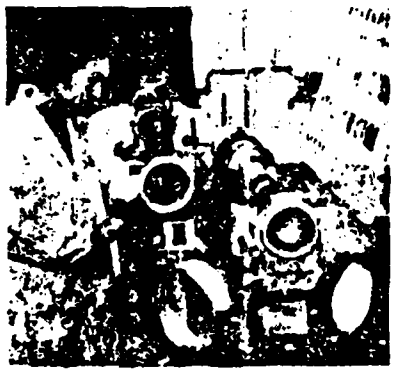
* "Nanosecond electro-photo crystal box", "Acta Physica Sinica" 1966, 22, no. 9, 1103.



Observation of sodium fluorescence in
an atomic laser spectroscopy laboratory.

including "On the Raman effect of high order radiative process and its applications"***, "The radiative behavior of molecules in an unmodulated cavity and the double-cavity maser phenomena"****, "The stability of light excited emission"*****, "On the line width of light excited emission devices"****** and "On the frequency modulator of three energy levels"*******, etc.

Since 1969, the laboratory has been expanded substantially in view of the prospect of laser applications. The number of employees has been increased to more than 70. At that time the effort was concentrated on two major topics: Develop a laser large screen color TV and optical communication data base of a radar signal two-dimensional display*. Ar, Kr ionic laser devices, crystal electro-photo modulator, light deflector, etc., were developed subsequently. In order to investigate the mini light source of a laser TV, a semiconductor laser device research group was formed. In the meantime, other applied research was initiated. As a result, a high power CO_2 laser device research group was organized. $TEACO_2$ laser device as well as electron beam preionization pulsed CO_2 laser device controlled by a cooling anode electron gun were developed. Research on the YAG laser device and the growth of the $LiIO_3$ nonlinear crystal was performed, along with the study on the laser controlled fusion separation of isotopes** (see page 4), earthquake forecasting, etc.

In the 1970's, the laboratory was oriented toward basic research and upgrading efforts, together with the development of

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* "Data base management of pulsed Doppler radar optical communication", "Laser Journal", 1977, 4, no. 6, 25.

*** H. Y. Li, "Acta Physica Sinica", 1964, 20, no. 1, 164.

**** T. C. Li, L. Z. Fong, "Acta Physica Sinica" 1964, 20, no. 8, 753.

***** U. P. Fuo, "Acta Physica Sinica", 1964, 20, no. 10, 954.

****** "Acta Physica Sinica", 1964, 20, no. 11, 1079.

******* "Acta Physica Sinica", 1964, 20, no. 12, 1199.

laser spectroscopy. They launched out research on related laser devices, such as the nitrogen molecular laser, nitrogen molecular pumping dye laser, Ar ion pumped tunable dye laser, flash lamp direct pumping pulsed dye laser and nonlinear effect parametric laser. As for the data base of optical communication, research on basic problems was enhanced and general linear transform theory (non-Fourier transform) was developed***, with the performance of corresponding experimental confirmation. A theory on the treatment of large obscured dynamic pictures with non-interfering light was proposed, in which the compensation method with positive, negative slices of $\gamma = 1$ was used to realize the redisplay of those large obscured rotational pictures****. Progress was also made on the materials for wide-angle quenching, color quenching and quenching photography. Besides, the laboratory is a leading one in the realization of continuous operation of heterojunction semiconductor laser devices at room temperature, high power single frequency output of Ar ion laser devices, output of double frequency ultra-violet laser, etc.

For the last three years, the laboratory was actively involved in research on the microscopic dynamic physical processes of the interaction of light and matter, data bases for optical communications, new laser devices, nonlinear optics and thin film optics. A theoretical research group was formed and an atomic

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** "On the separation of boron isotopes by infrared multi-photon absorption", "Laser Journal", 1979, 6, no. 11, 11.

*** "Realization of orthogonal transformation and general linear transformation", "Acta Physica Sinica", 1975, 24, no. 6, 438; 1976, 25, no. 1, 31.

**** "Management of large mobile obscured pictures with non-interference light", "Acta Physica Sinica" 1976,25,No.2,124.

***** "Non-resonance emission spectra of the sodium atom first excited state", "Physics", 1979, 8, no. 5, 394.

****** "Theory of the multi-photon induced dissociation of multi-atomic molecules under the interaction of an intense infrared laser field", "Acta Physica Sinica", 1978, 27, no. 6, 664.

laser spectroscopy laboratory was constructed. In the observation of the sodium fluorescent spectra incurred by the near resonant excited collisions, the fine structure transition cross-section of the sodium D line and its dependence on the environmental conditions were measured***** (see page 4). The laboratory is also developing detection techniques for single atom or minor atoms. As for the research on the interaction of intense lasers and molecules, they presented a nonlinear theory regarding laser induced dissociation of multi-atomic molecules in the intense infrared field****** (see page 4). The theory interprets the dissociation rate of SF_6, nonlinear reaction processes of internal mode coupling single molecules, along with the phenomenon of selective molecular dissociation of isotopes. During the observation and experimentation with molecular spectra, they systematically observed the dissociation process of BCl_3 visible fluorescence induced by the absorption of infrared multiphotons, and corrected the empirical expression of $P\tau_{extended} \sim 2.3 \mu sec.Torr$ which, they concluded, should be more accurately expressed as $P\tau_{extended} \sim \frac{C}{K(T_v)}$. They also discovered the photon-phonon-photon process of visible fluorescence which demonstrates an obvious nonlinear characteristic. The discovery apparently raises a new research topic related to the nonlinear relaxation of the interaction of light and molecules, physical mechanics, chemical physics, laser separation of isotopes, etc. In the study of nonlinear optics, they observed the four-wave mixed frequency effect in liquid crystals which was employed to study the phase transition and relaxation of liquid crystals and develop a nonlinear theory on the interactions between three photons*. In addition, the photon statistical theory was developed**. As for the data

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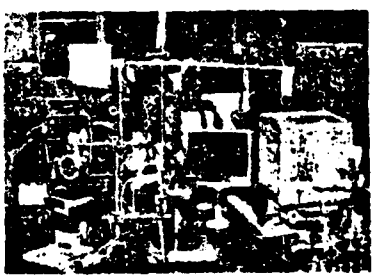
* "Three-photon vector model", "Acta Physica Sinica", 1979, 28, no. 5, 630.

**"The statistical behavior of the relation between the striped pictures of partial polarization and the uniform interference background", "Acta Physica Sinica", 1978, 27, no. 4, 375.

management of optical communications, they employed techniques of non-interfering light produced false color codes and successfully coded black and white film with color codes***. In the meantime, they applied the nonlinear characteristic to realizing the division of density. Other achievements include research on the extended dynamic range of off-focus obscured pictures, research on the optical Walsh transformation, etc. In laser device research, devices with wave block from ultra-violet to middle infrared have been developed for operating times from the subnanosecond range to continuous operation. Devices with various powers and various designs are either being developed or have been applied to scientific experiments.

The scientists in this laboratory are trying to catch up with the frontiers in the world in their own fields. They are prepared to make more contributions to the goal of the four modernizations.



Laboratory for data management of optical communications in operation

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***"Realization of pictorial false codes with nonlinear optical transitions", "Laser Journal", 1978, 5, no. 5-6, 44.

NEW INDUSTRY

The emergence of any new technology implies the application of the technology to society and the benefit to human beings. The steam engine in the 18th Century, electricity in the 19th Century and current nuclear energy have been historical facts. In the early stages of electronic technology, or more than 50 years ago, no one expected it to develop and have the importance to society that we have today. The emergence of laser technology immediately found applications. Other technologies are hardly compatible with this new technology. Today, after 20 years of development, many research results consequently step out of the laboratories and move toward industrial production and enable the upgrading quantity and quality of industrial products. These laser apparatus have become necessary components in production lines. Laser hole-drilling, for instance, has been an important procedure in the production line for axle pivots in the clock and watch industry. Laser cutting, laser micro welding, laser measurement and detection, laser calibration, laser precise distance measurement, etc. have demonstrated their important functions in electronics, metallurgy, transportation, construction, the textile industry, chemical engineering, machinery, etc. Undoubtedly, laser technology and laser apparatus will become more and more important in industry. On the other hand, materials, components and component technology required in the development of laser technology are being produced more and more. Eventually it will evolve into a new laser industrial system.

The rise of this new industry has drawn extensive attention. Many scientists suggest that substantial assistance to this industry should be given by the government**** and a laser plant should

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****"Photons, photon technology, photon industry", "Laser Journal", 1979, 6, no. 1, 1.

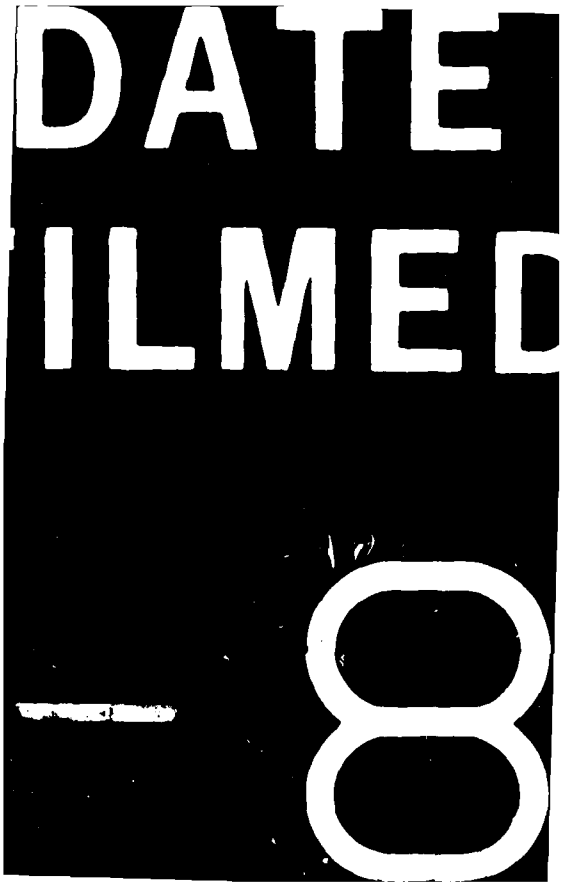
be established to expedite extensive applications*****. We realize that a moderate foundation has been laid for the laser industry in China. Several industrial divisions (Division 1, Division 3, Division 4 and Division 5) have already set up substantial product facilities with a number of devices produced. The key element, however, will be a unified organization which can intensify the leadership, solve problems in time regarding the system and policy, and coordinate research, development, product and sales, so that the new laser industry can be built up step by step.

In a laser conference held in Mouganshan in August, 1979, the National Committee of Science decided to emphasize "4 categories, 8 types" of laser devices and apparatus in order to solidify and upgrade the quality of laser products. The committee then initiated a nationwide workshop on laser devices held in Tenjin in November of the same year******. In the workshop, schedules were set up for technical research, testing, production regarding some urgently needed laser devices. The two-year development plan covers 7 popular laser devices--He-Ne laser, CO_2 laser, Ar^+ laser, Nd:YAG laser, ruby laser, Nd: glass laser, tunable dye laser, 4 laser materials--ruby laser crystal, ND:YAG crystal, laser dye, nonlinear crystals and 7 subsidiary components--various pumping lamps, laser reflective film, laser deflective mirror, photoelectronic modulator, acoustic-optical modulator, calibrator, laser energy-storage capacitor.

It is predictable that these operations will certainly enhance and expedite the development of laser applications in China. Moreover, we can predict that a solid foundation will be laid for future expansion of the laser industry. (END)

***** "Liberation Daily", page 2, Feb. 3, 1979.

******"National workshop on laser devices supported by the National Committee of Science", "Laser", 1980, 7, no. 1, 12.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